Swift Observations of GRB 070420

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1 Introduction

At 06:18:13 UT, on April 20, 2007, BAT triggered on GRB 070420 (trigger #276321) (Stamatikos et al., GCN Circ. 6330). This was a long GRB with a T_{90} of 77 seconds in BAT. Swift slewed immediately allowing for XRT and UVOT follow-up observations at T+99 and T+109 seconds, respectively, resulting in the detection of afterglow candidates, with independent confirmation of the latter via ground based optical observational campaigns. Our best localization is from the UVOT afterglow position of RA, DEC (J2000) = 8h 4m 55.17s, -45d 33′ 20.0″ (Immler et al., GCN Circ. 6336), which is consistent with the XRT and BAT error circles.

2 BAT Observations and Analysis

Using the data set from T-239 to T+963 sec telemetry down-links, further analysis of BAT GRB 070420 was performed by the Swift team (Parsons et al., GCN Circ. 6342). The BAT ground-calculated position is RA, Dec (J2000) = 121.245 deg (8h 4m 58.7s), -45.564 deg (45d 33′ 50.6″) with an uncertainty of 1 arcmin, (radius, sys+stat, 90% containment). The partial coding was 8%.

The mask-weighted light curve (Figure 1) is described by a slow rise at T-50 to double-peaks at T+2 and T+8 sec, with subsequent gradual decay spanning to T+70 sec. The T_{90} (15-350 keV) is 77 ± 4 seconds (estimated error including systematics).

The time-averaged spectrum from T-29 to T+100 sec is best fit by a power law with an exponential cutoff. This fit gives a photon index[1] of 1.16 ± 0.24 and an E_{peak} of 114 ± 42 keV ($\chi^2 = 50.74$, for 56 d.o.f.). For this model, the total fluence in the 15-150 keV band is $1.4 \pm 0.04 \times 10^{-5}$ ergs/cm^2 and the 1-sec peak flux measured from T+1.40 sec in the 15-150 keV band is 7.1 ± 0.8 photons/cm^2/s. All the quoted errors are at the 90% confidence level.

3 XRT Observations and Analysis

The XRT began observing the field at 06:19:52 UT, 99 seconds after the BAT trigger and found a bright, fading and previously uncatalogued X-ray source. Using the first four orbits of Swift XRT data on GRB 070420, further analysis was performed by the Swift team (Stratta et al., GCN Circ. 6337). Using a total exposure of 573 sec in Windowed Timing (WT) mode and 7.5 ks in Photon Counting (PC) mode, a refined XRT position[2] was derived at RA, DEC (J2000) = 121.2301 deg (8h 4m 55.22s), -45.5563 deg (-45d 33′ 22.6″), with an error radius of 3.5 arcsec (90% confidence). This position is 62.3 arcsec from the BAT position (Stamatikos et al., GCN Circ. 6330), 0.8 arcsec from the initial XRT position (Stamatikos et al., GCN Circ. 6330) and 2.6 arcsec from the UVOT refined optical counterpart position (Immler et al. GCN 6336).

The $0.3 - 10$ keV X-ray light curve (Figure 2) presents a steep decay between T+106 sec and T+300 sec followed by a plateau phase up to about T+2ks (end of the first orbit). The last three orbits of

[1] A fit to a simple power law gives a photon index of 1.59 ± 0.05 ($\chi^2 = 61.25$, for 57 d.o.f.).

[2] N.B.- The RA decimal degree value for the refined XRT position given in Stratta et al., GCN Circ. 6337 was inadvertently 0.3 arcsec higher than the correct value given in h:m:s format. This error has been corrected in this report and, although it was an order of magnitude smaller than the quoted 3.5 arcsec error radius, we apologize for any inconvenience that this may have caused.

data, taken in PC mode, show a new steepening of the light curve, from T+5ks to T+18.5 ks (end of the third orbit). The light curve from T+106 sec to T+18.5 ks is well fit by a double broken power law model with decay indices: $\alpha_1 = -4.4 \pm 0.2$, $\alpha_2 = -0.2 \pm 0.1$ and $\alpha_3 = -1.5 \pm 0.1$, with the first break and second breaks occurring at $t_1 \sim T + 230$ s and $t_2 \sim T + 3.2$ ks, respectively.

The $0.3 - 10.0$ keV X-ray spectrum from the XRT/WT data during the decay phase is well fit by an absorbed power law with a photon index of 2.6 ± 0.1 and a total column density of $(4.1 \pm 0.3) \times 10^{21} \mathrm{cm}^{-2}$. The X-ray spectrum from the XRT/PC data during the flat decay phase (corrected from the pileup effects) can be fit by an absorbed power law with a photon index of 2.0 ± 0.2 and a total column density of $(5.0 \pm 1.0) \times 10^{21}$ cm^{-2}. We note that the Galactic column density in the direction of the source is 3.7×10^{21} cm^{-2} [*Dickey & Lockman, ARAA 28:215-261 (1990)*].

Assuming the X-ray emission continues to decline with decay index α_3, we predict a $0.3 - 10.0$ keV XRT count rate of 1.3×10^{-2} count/s at T+24h and 4.7×10^{-3} count/s at T+48h, which corresponds to an observed $0.3 - 10.0$ keV flux of 7×10^{-13} ergs/cm^2/sec and 2.5×10^{-13} ergs/cm^2/sec, respectively.

4 UVOT Observations and Analysis

UVOT began settled observations of GRB 070420 at T+109 sec. The revised UVOT position[3] of the afterglow is RA(J2000) = 8h 4m 55.17 s, Dec(J2000) = -45d 33′ 20.0″, as reported in Immler et al., GCN Circ. 6336. We estimate a statistical accuracy of 0.2 arcsec radius (90% confidence), but with a systematic uncertainty of the aspect solution of about 0.5 arcsec.

The afterglow is detected in all UVOT optical filters (Figure 3). The large reddening, E(B-V) = 0.52, might explain the non-detection in the UV. This large extinction may also account for the observations noted by Klotz et al., GCN Circ. 6332. The flux is decaying with $t^{-0.7}$ in the White for times between T+500 sec and T+10 ksec. The photometry results are given for the 7 UVOT filters in Table 1.

Preliminary V-band follow-up observations of the afterglow indicate possible re-brightening of the OT between T+2.3 ksec and T+8.64 ksec, as reported in Jelinek et al., GCN Circ. 6338. Unfortunately, UVOT data is not complete during this interval, as can be seen from the light curve of the White filter (Figure 4). The other optical UVOT filters (V, B, U) do not reveal re-brightening. Hence, we cannot confirm any re-brightening of the OT with UVOT data at this time.

Filter	T_{Start} (sec)	Exposure Time (sec)	Magnitude
White	109	99	17.4 ± 0.1
	7125	197	20.8 ± 0.1
V	90	10	17.9 ± 0.1
B	693	10	18.8 ± 0.1
U	669	20	21.1 ± 0.1
UVW1	645	20	>20.4 (3σ)
UWM2	620	20	>20.8 (3σ)
UVW2	723	20	>20.8 (3σ)

Table 1: UVOT photometry results for the optical afterglow of GRB 070420. N.B. - The above magnitudes have not been corrected for extinction.

[3]The UVOT position sent out as a GCN notice gave an invalid position while Stamatikos et al., GCN Circ. 6330 had the correct position. We regret any confusion this might have caused.

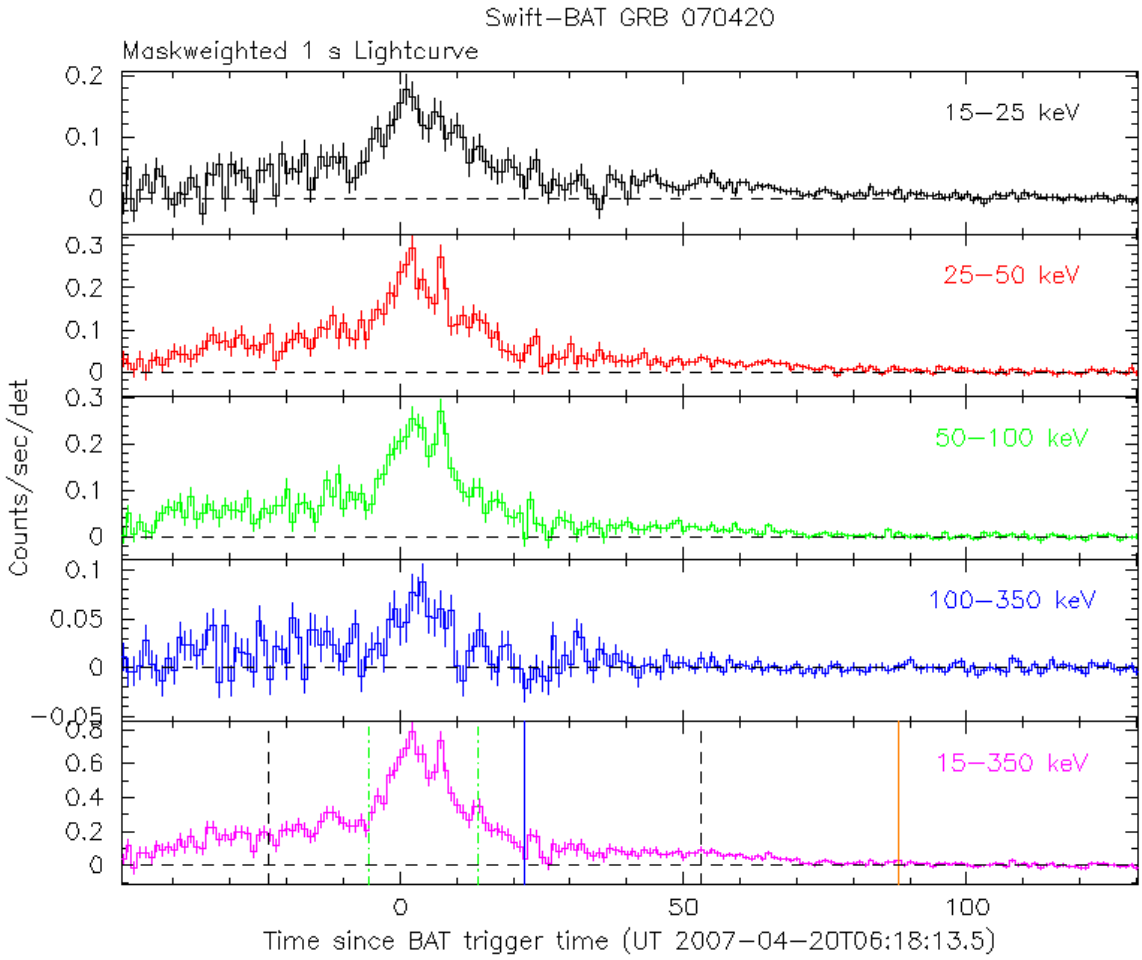

Figure 1: BAT Light curve for GRB 070420. The mask-weighted light curve in the 4 individual plus total energy bands. The green and black dotted lines bracket the T_{50} and T_{90} intervals, respectively, while the blue and orange solid lines bracket the start and end of the slew, respectively. The time of each bin is in the middle of the bin. The units are counts/sec/illuminated-detector and T_0 is 06:18:13 UT.

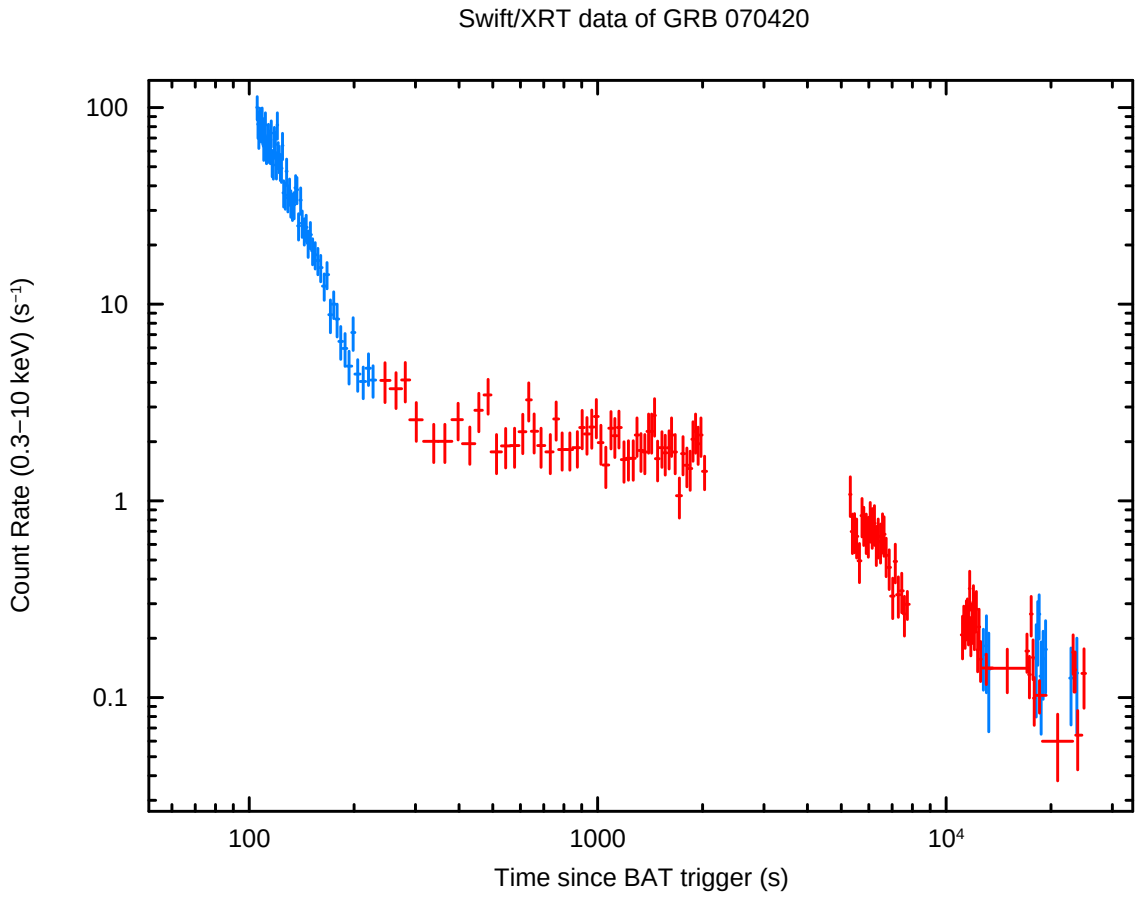

Figure 2: XRT light curve of GRB 070420, in the $0.3 - 10$ keV energy band, for windowed timing (blue) and photon counting (red) modes. The approximate conversion is 1 count/sec $\approx 5.35 \times 10^{-11}$ ergs/cm^2/sec.

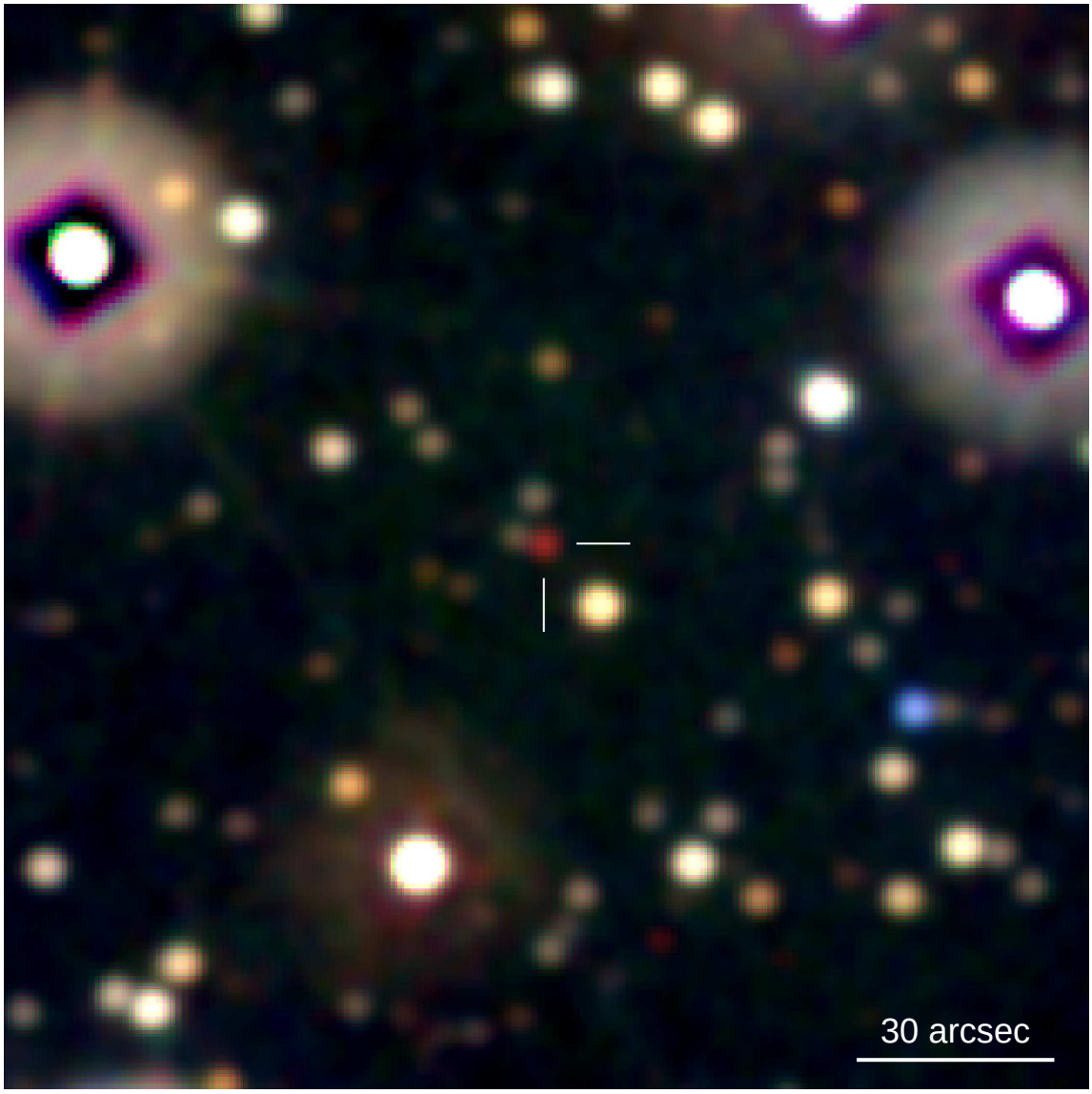

Figure 3: Composite V, B, and U image from UVOT observations of GRB 070420. The white hash marks indicate the afterglow position. The image is from the combined exposures of 2.1, 1.2, and 1.4 ksec for V, B and U filters, respectively.

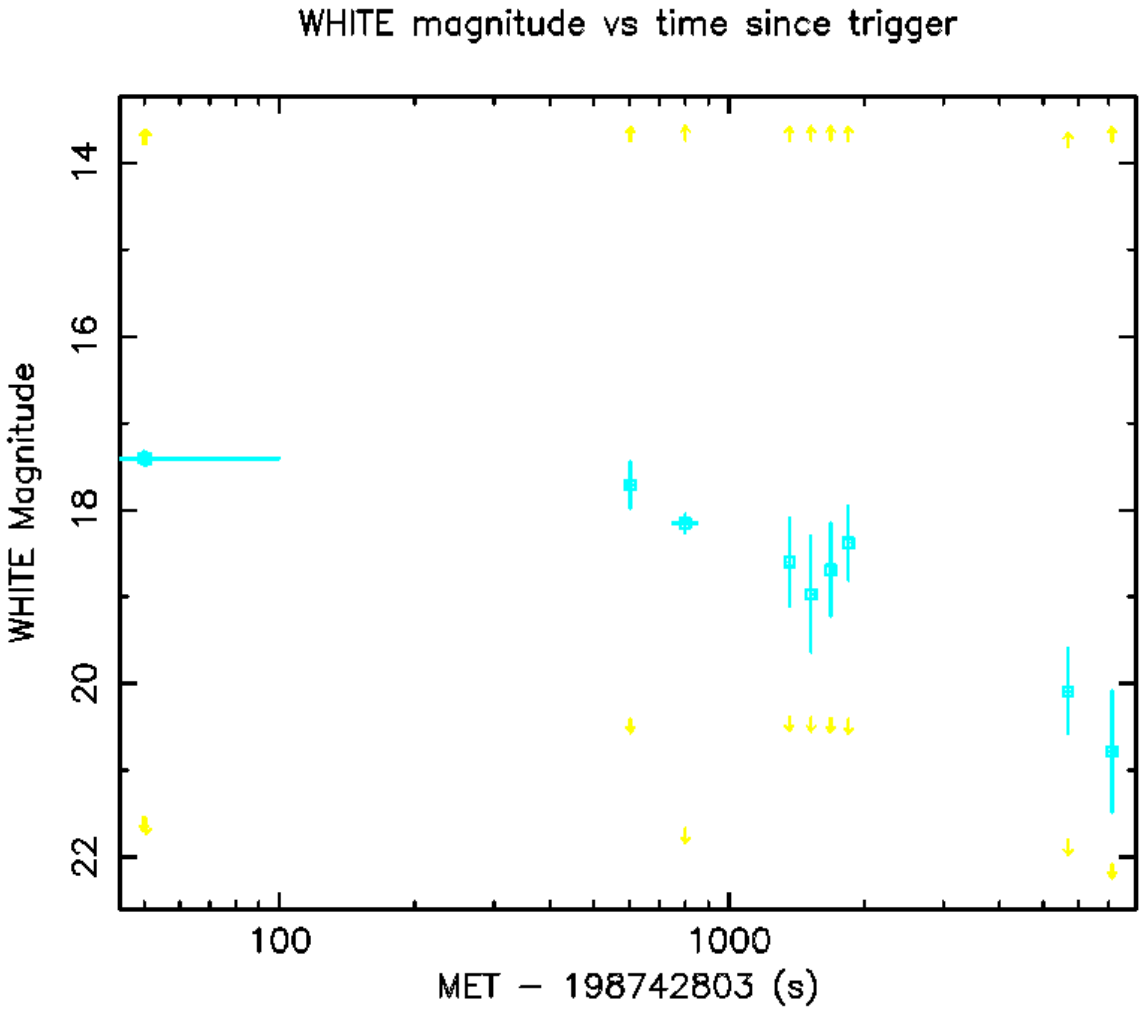

Figure 4: UVOT light curve for GRB 070420 using the White filter. The possible a re-brightening at $\sim T + 1.5$ ksec is not statistically significant. N.B. - The first data point has an erroneous start and end time (bug in the command). The others are correct and we will update this plot in the next version of this report.